The PLATO Mission Status
(PLAnetary Transits and Oscillation of stars)

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The PLATO Mission Consortium

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The PLATO Mission

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- **Prime mission goals**:
  - detect and characterize a large number of extrasolar transiting planets including **Earth-sized planets up to the habitable zone of solar-like stars**
  - investigate seismic activity in stars, enabling the precise characterisation of the planet host star, including its **age**

Image credit: OHB

- **Payload design drivers:**
  - **Planet detection**

    → large number of target stars
  - **Planet and star characterization**

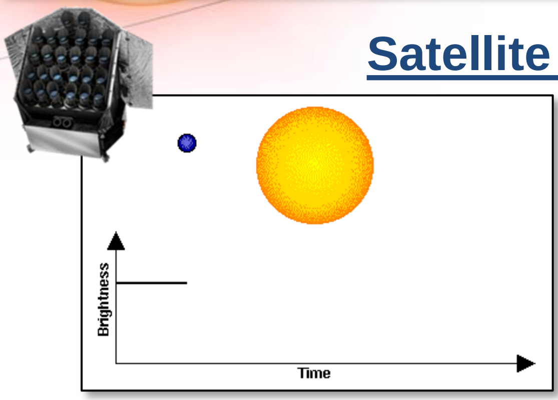
    → bright target stars → wide field-of-view

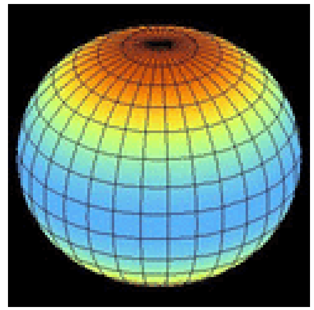
→ **multi-camera approach:**
  - 24 normal cameras (<u>photometry</u>)
  - 2 fast cameras (<u>fine-guidance</u>, broadband photometry red and blue)

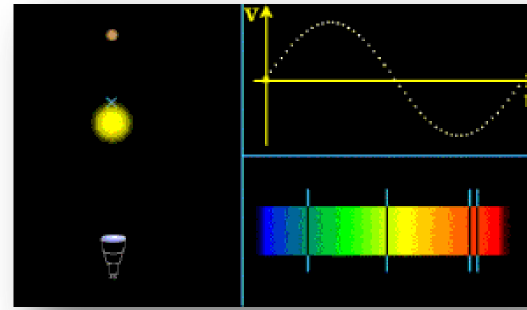
PLATO methods

<u>Satellite photometry</u>

<u>Ground-based spectroscopy</u>







Transit detection

→ Planet/star radius ratio
→ Inclination

Asteroseismology

→ Stellar radius, mass
→ Stellar age

RV spectroscopy

→Planet radius
→Planet age

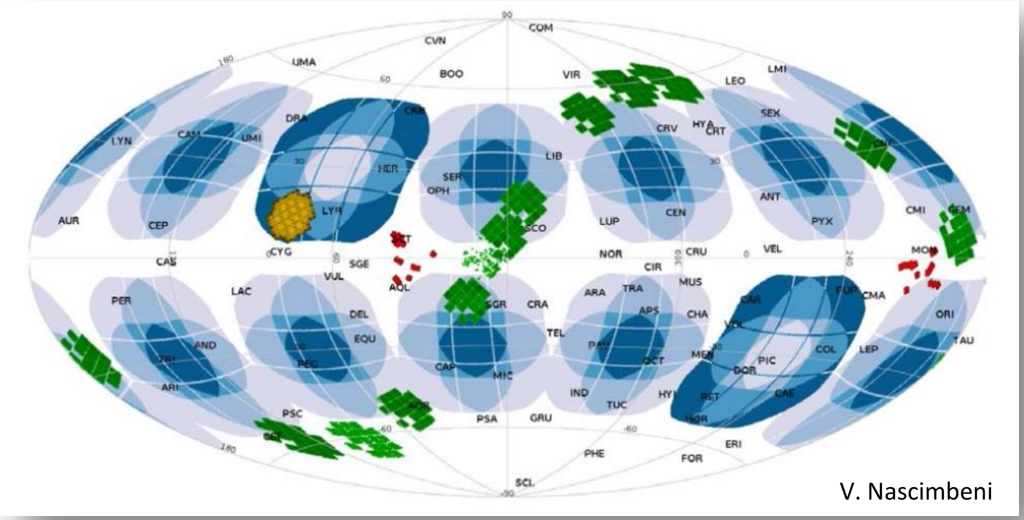
→ Planet mass

<u>The PLATO precision benchmark case: An Earth around a Sun at V=10 mag:</u>

 **→ 3% radius; → 10% mass; → 10% age**

PLATO Baseline Observing Scenario

- Launch end 2026 into orbit around L2 Earth-Sun Lagrangian point.
- Mission science operations: 4 years duration.
- Satellite/instrument designed to last with full performance for 6.5 years.
- Consumables will last 8 years.



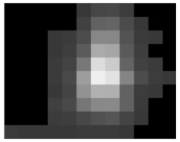
- **Observing strategy:**
  - **Baseline:**
    2 long pointings of 2 years
  - Alternative:
    3 years + 1 year step-and-stare phase

- The final observing strategy will be fixed 2 yrs before launch and can be adapted during the mission.

Stellar samples

- PLATO has a set of lightcurve samples defined with different precision.
- The main samples are:
  - **Core sample:** ~15 000 dwarf and sub-giant stars (F5 to K7) with <11 mag
    - Lightcurve sampling: 25 s
    - Imagettes transmitted for analysis on ground
    - 34 ppm in 1 hour for <10mag; 50 ppm for <11 mag

    → high precision planet and stellar parameters (radii, asteroseismology)



  - **„Statistical“ sample**: >245 000 dwarf and sub-giant stars with <13 mag
    - Lightcurve sampling: 600 s, computed on board (50s for 10% sample)

    → statistics, good planet radii precision; but no asteroseismology, no RV

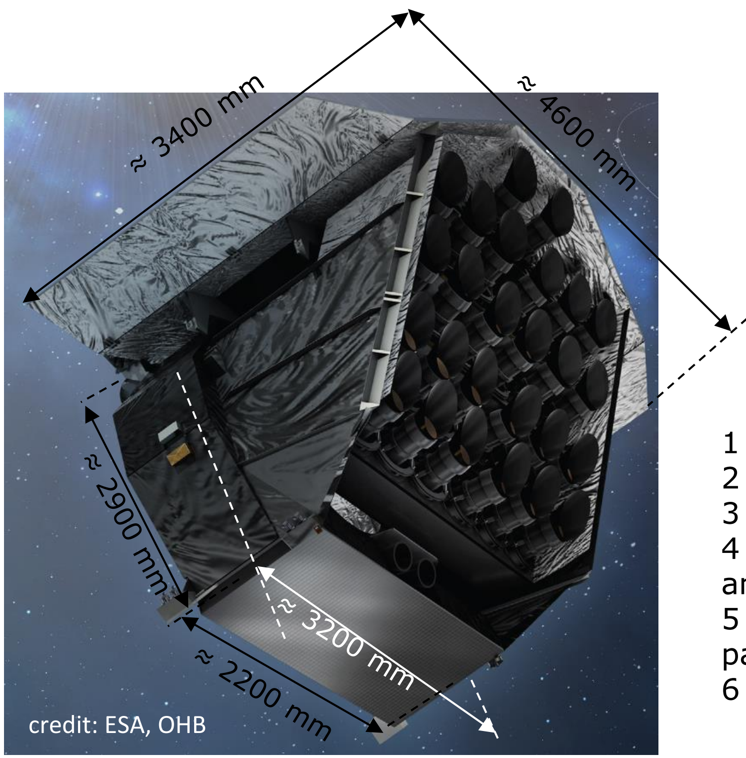
    → TTV analysis

    - For the brightest stars in the sample (<11 mag): Imagettes can be transmitted to ground with 25 s sampling

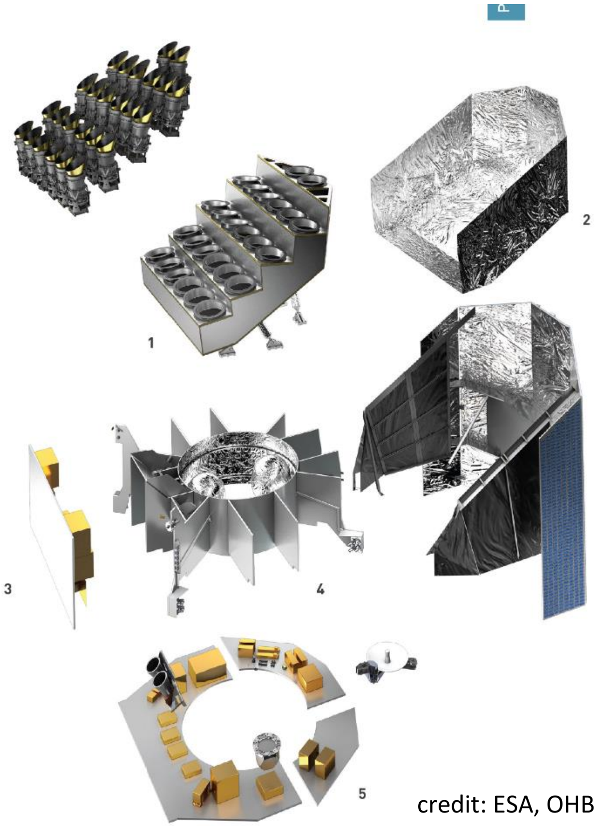
    → RV possible for planet mass determination

PLATO concept

PLATO is an ESA mission where the **PLATO Mission Consortium** (>112 institutes across Europe) provides the **payload** (26 cameras) and ESA procures the CCDs and signed the contract (in October 2018) with the **Prime industrial partner** building the **satellite** (**OHB** leading a team of 3 partners: **OHB**, **TAS**, and **RUAG**).



1 Optical Bench Assembly
2 Payload Thermal Shield
3 Payload Electronics Panel
4 Central Module (structure and propulsion)
5 Avionics and Electronics panels
6 Sunshield and Solar Array



credit: ESA, OHB

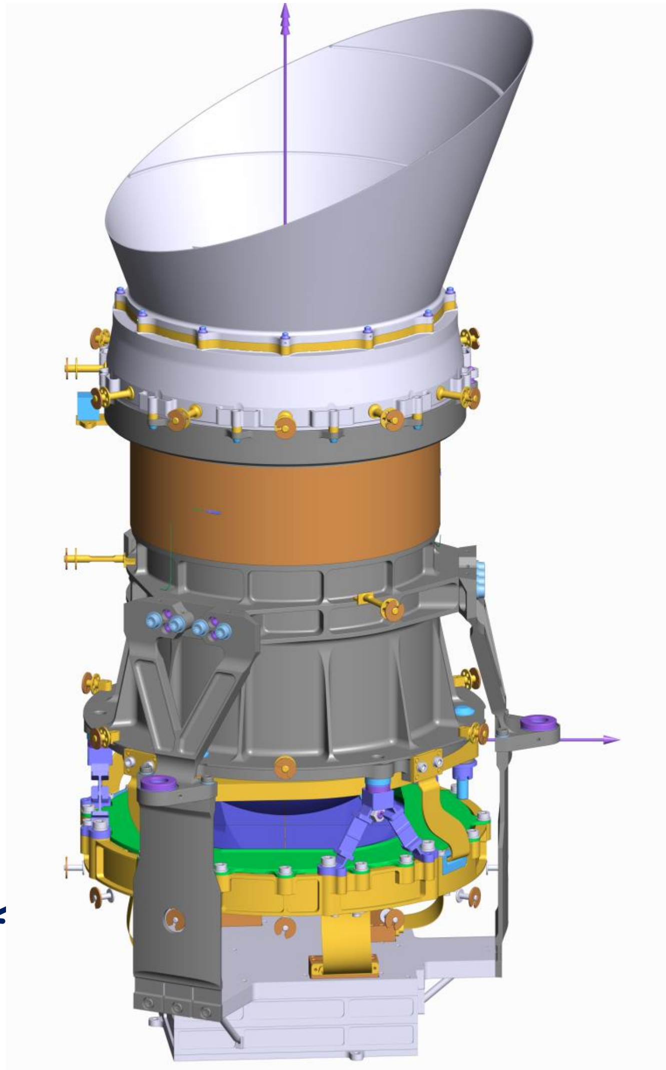
PLATO payload

24 Normal cameras:

- 12cm aperture telescopes
- range: ~8 (4) ≤ m_V ≤ 11 (13)
- FOV payload ~49°x 49°
- Each camera has 4 x CCD, each 4510×4510px
- Pixels size: 18 µm square
- read-out cadence: 25 sec
- operate in "white light" (500 – 1050 nm)

2 Fast cameras:

- read-out cadence: 2.5 sec
- one „red" & one „blue" camera

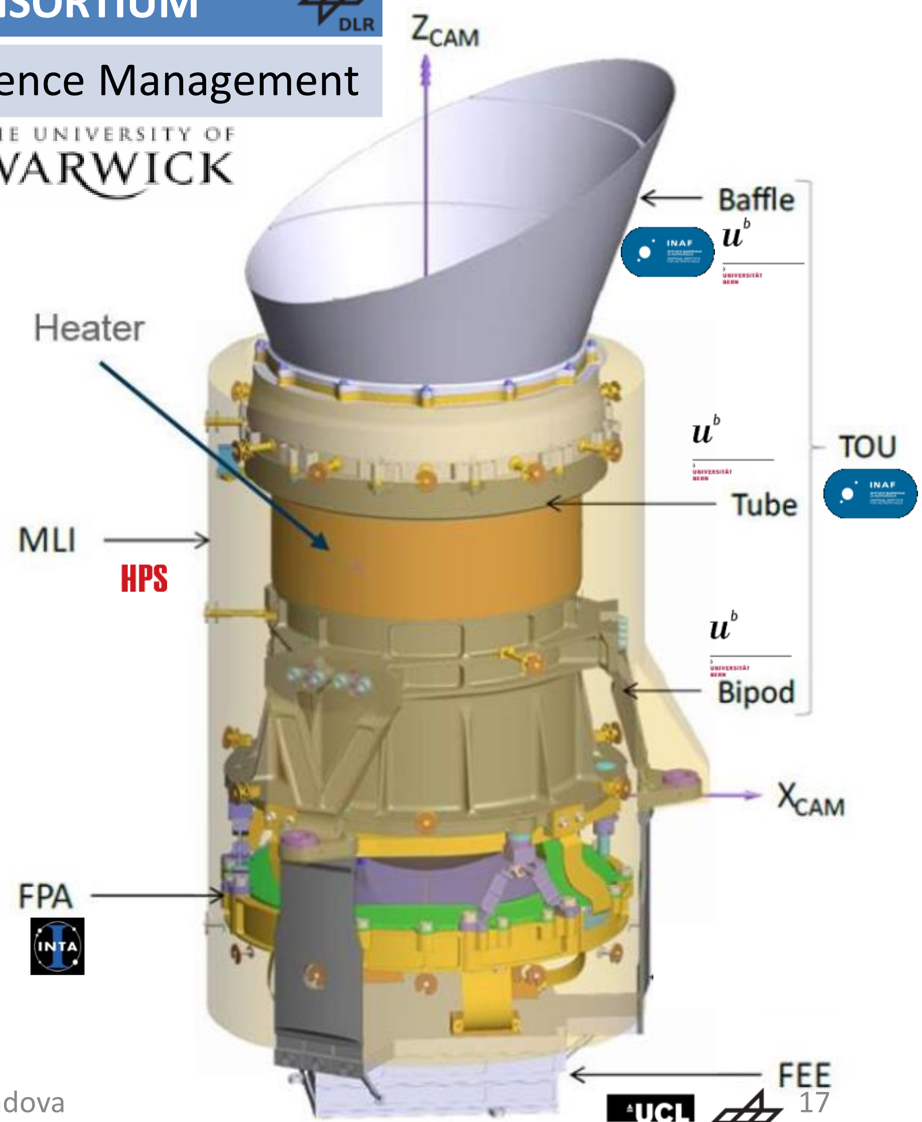


PLATO PMC Payload: main partners

PLATO MISSION CONSORTIUM		
Payload	Data Center	Science Management

The Payload is built by the Consortium:

- 24 normal cameras (25s)
- 2 fast cameras (2.5s)
    - Telescope Optical Unit
        - Tube
        - Baffle
        - Lenses
    - Focal Plane Assembly (4 CCDs/camera)
    - readout electronics
- Main Electronic Units (data processing)
- Instrument Control Unit (data storage)
- Ancillary Electronics Unit



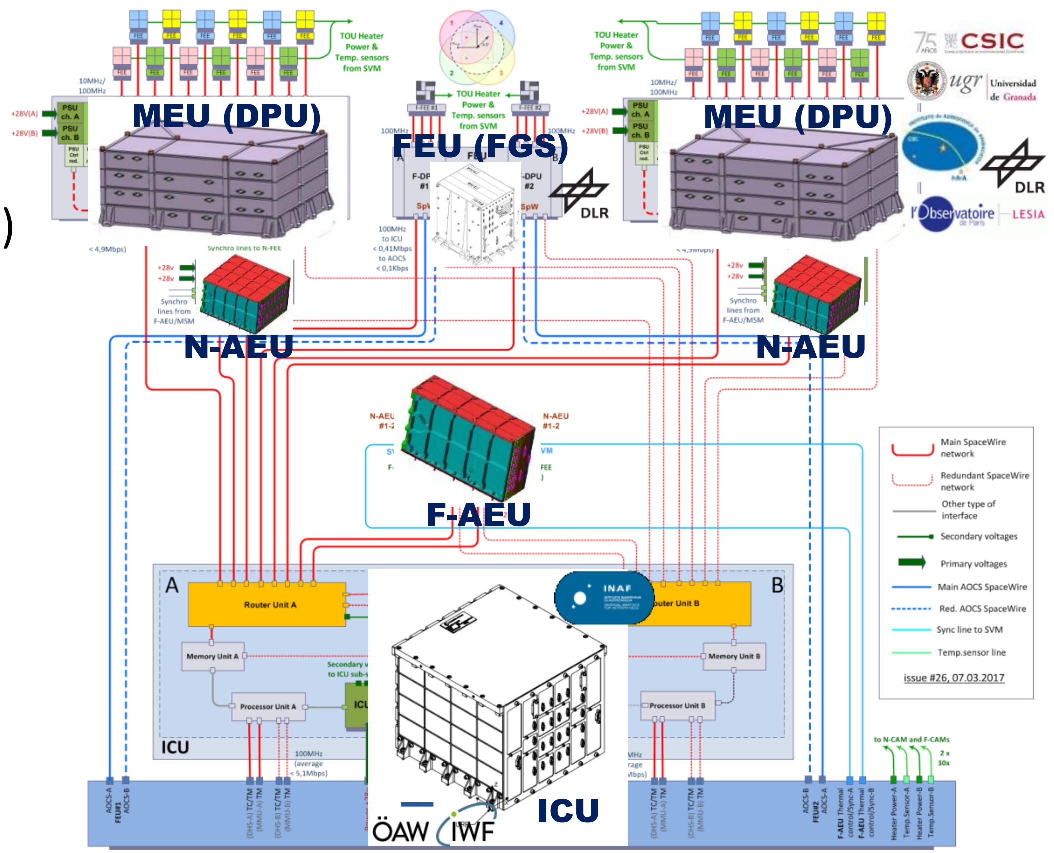
PLATO PMC Payload: main partners

AIT/AIV:

The Data Processing System includes:

- Main Electronic Units (data processing)
    - Data Processing Unit
- Instrument Control Unit (data storage)

The series production of cameras is one big challenge for PLATO. The capacity production of several institutes in Europe will be used to build the cameras and then test all the models (EM, QMs, FMs) before delivery to the Prime for integration in the spacecraft and launch.



transport containers:

schedule

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2014 Mission Selection
2015 **S**ystem **R**equirements **R**eview
2016
2017 Mission Adoption
2018 Instrument **P**reliminary **D**esign **R**eview
2019 Unit **P**reliminary **D**esign **R**eviews (x10); S/W **PDR**; S/C **PDR**
2020 start of tests at unit level
2021 Instrument **C**ritical **D**esign **R**eview; Ground Segment Requirements Review
2022 Software **C**ritical **D**esign **R**eview
2023 Ground Segment Design Review
2024 Last delivery of camera FM
2025 S/C AIT
2026 **Launch**
2027
2028
2029
2030 End of nominal operations period (4.5 yr, including 6 months commissioning)
2031
2032
2033 End of (possible) extended operations period (6.5 yr)

ESA (→Prime)

SIS1

SIS2

S/C AVM

S/C PFM

Year:

2034

OHB

EM /EQM Test Bench

PFM Test Bench

Click to start animation

DLR(@OHB)

DPS Test Bench

PLATO

Planetary Transits and Oscillation of Stars

PMC

ICU EM1 | ICU EM2 | ICU EQM | ICU PFM | MEU EM | MEU EQM | MEU PFM | MEU FM

FEU EM | FEU EQM | FEU PFM | NAEU EM | NAEU EQM | NAEU PFM | NAEU FM

FAEU EM | FAEU EQM | FAEU PFM

N EM | N QM | N FM1 | N FM2 | N FM3 | N FM4

SimuC 1 | SimuC 2

F EM | F QM | F FM1 | F FM2

A new era of planetary sciences

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PLATO will detect transit signals of thousands of planets which are bright enough for radial velocity spectroscopy to determine their masses.

PLATO will provide:

- **A sample of well characterized "Earth-Sun" analogues (Earth-like planets around solar-like stars)**

  → unique to PLATO

- Small-planet diversity – how unique is Earth?
- Planets at all ages, understand planet evolution.
- Provide a target list for atmosphere spectroscopy → JWST, ARIEL, ELT

final remarks

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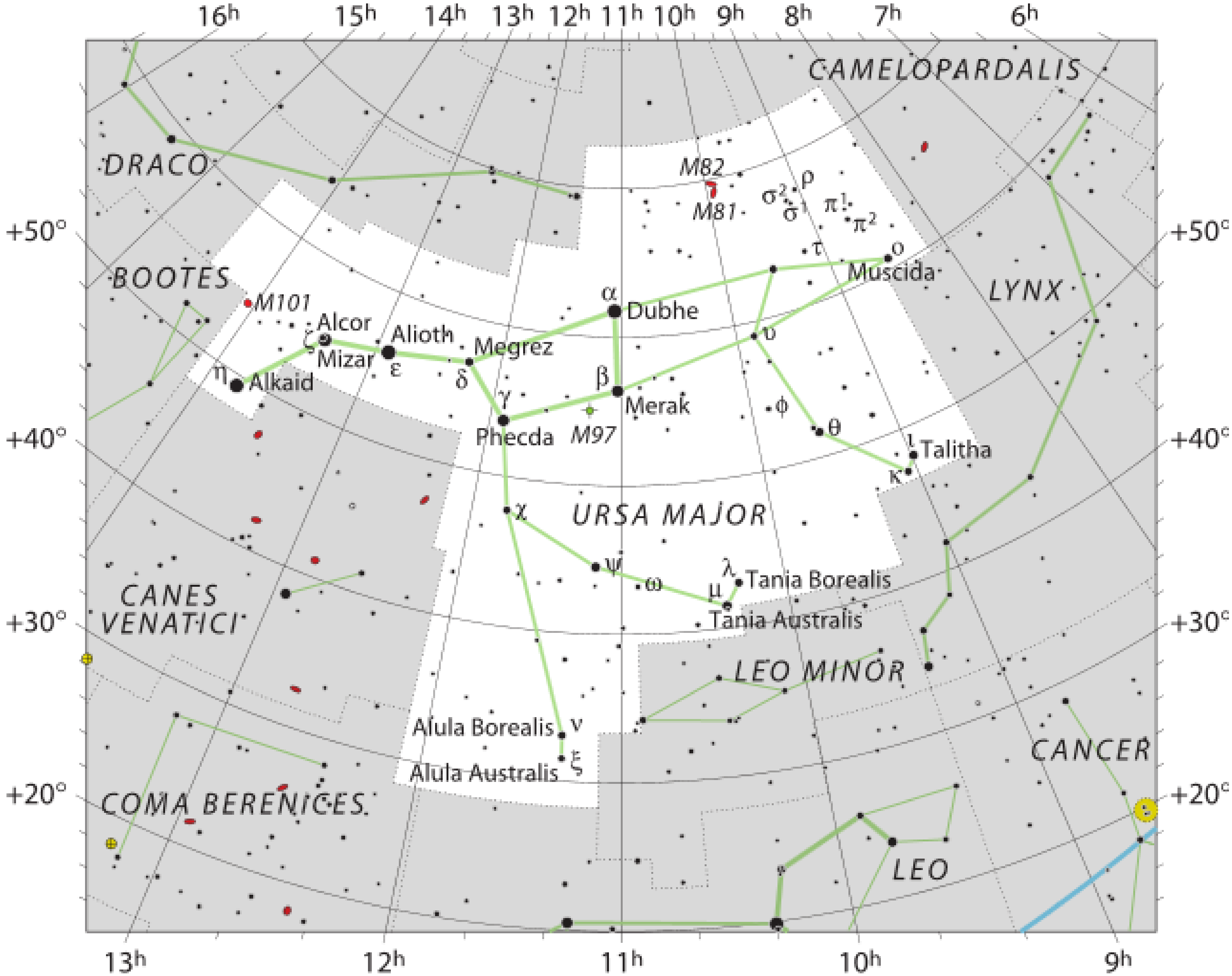
https://platomission.com/

@PLATOMissionCon

plato-consortium@dlr.de

19-22 November 2019: PLATO STEllar SCIence work package Workshop III
Barcelona
https://www.ice.csic.es/indico/event/18/

If interested in PLATO science and not yet in the team, please contact: plato-consortium@dlr.de


16h 15h 14h 13h 12h 11h 10h 9h 8h 7h 6h
+50° +40° +30° +20°
13h 12h 11h 10h 9h
CAMELOPARDALIS
DRACO
BOOTES
LYNX
URSA MAJOR
CANES VENATICI
LEO MINOR
CANCER
COMA BERENICES
LEO
M82
M81
M101
M97
Dubhe
Merak
Megrez
Alioth
Alcor
Mizar
Alkaid
Phecda
Muscida
Talitha
Tania Borealis
Tania Australis
Alula Borealis
Alula Australis
1 2 3 4 5 6

transits detection status

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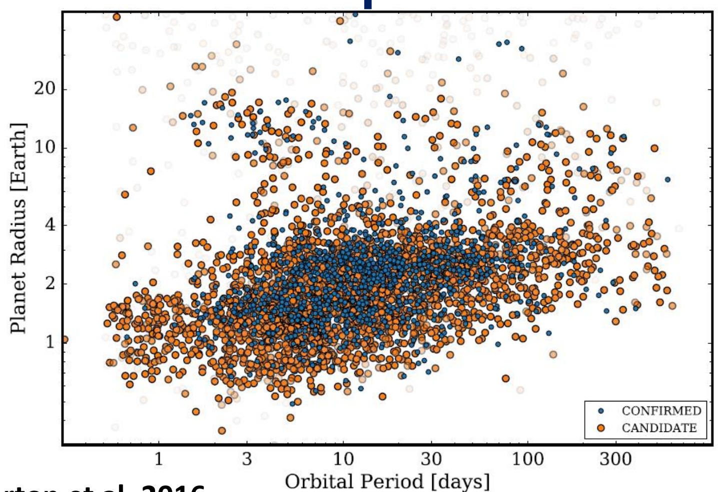
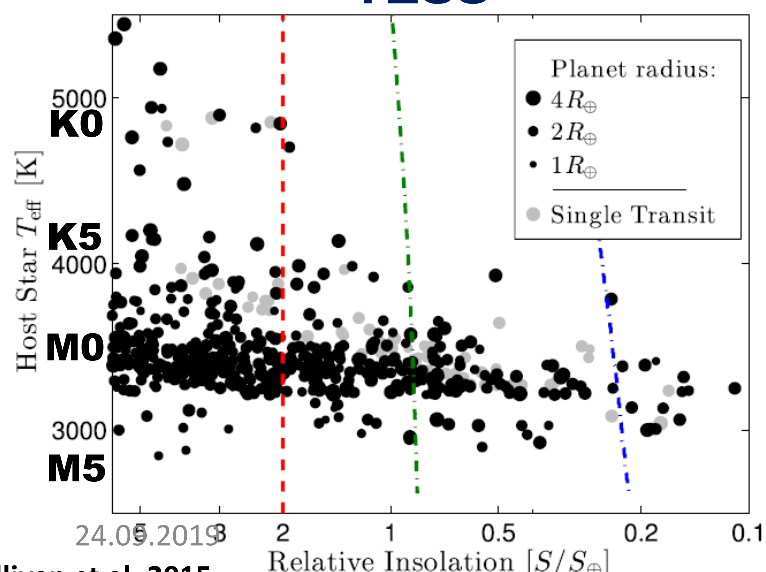
Kepler



Morton et al. 2016

TESS



Sullivan et al. 2015

Kepler:

- >~7000 KOIs
- ~1000 'confirmed' planets
- ~90 planets with RV measurements

K2:

- ~70 planets with RV measurements

TESS

- ~20 planets with RV measurements

CoRoT:

- 36 planets with RV measurements

Ground-based:

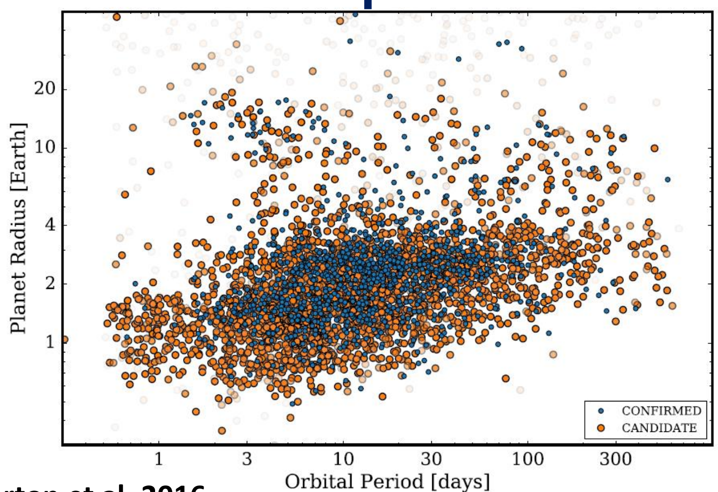
- ~350 planets with RV measurements

Total: ~500 planets with radii & masses,
- but only <30 planets with <2 Rearth
and 0% are in HZ of solar-like stars

LHS 1149b (RV) and the Trappist system (masses with TTVs) orbit a M dwarfs

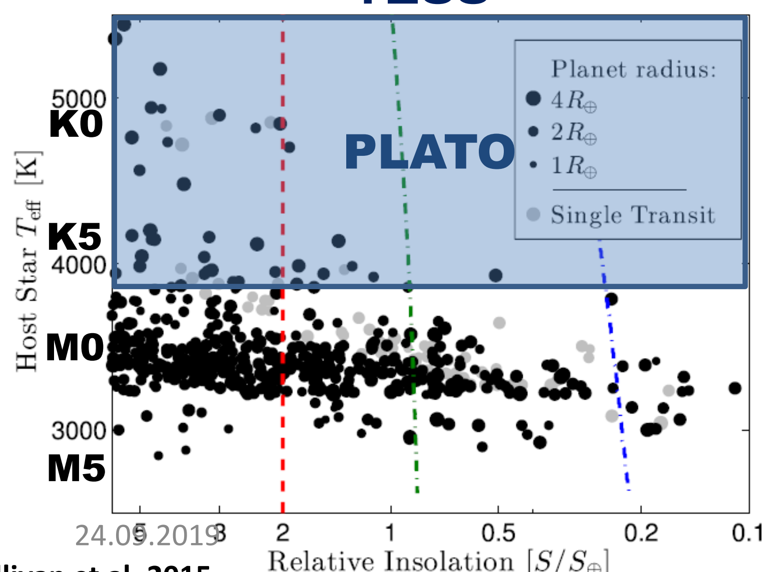
transits detection status

Kepler



Morton et al. 2016

TESS



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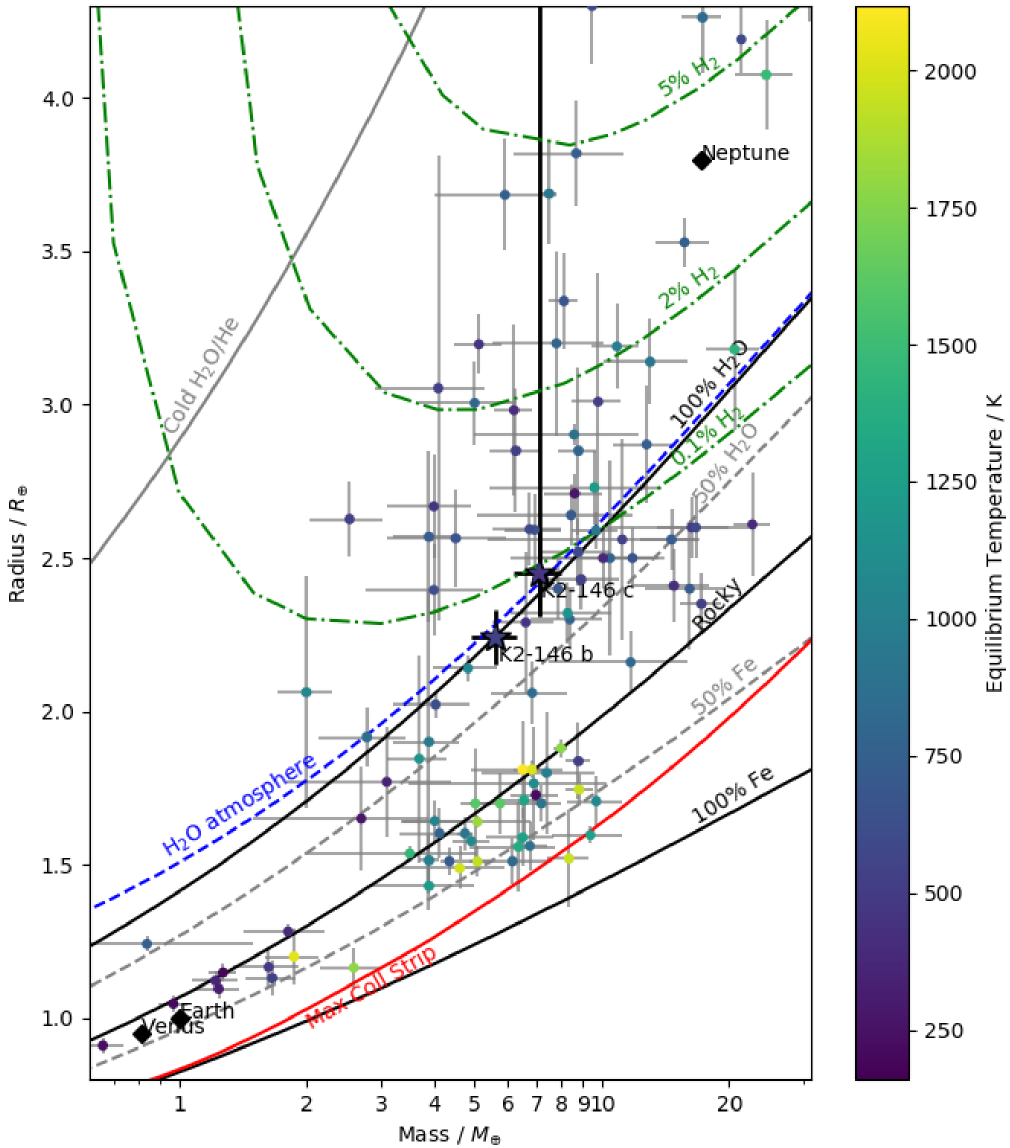
precise planet characterization



updated from **Lam et al. 2018, A&A, 620**

Precise characterization of planetary bulk parameters is required to understand the planetary interiors.

Detailed understanding of planetary interiors and planetary atmospheres gives insight into the planetary formation and evolution processes.

what HPP photometry can offer

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- HPP observations can potentially give access to:
  - Surface (differential?) rotation of hundred to thousand stars [e.g. McQuillan et al. 2013, 2014; Nielsen et al. 2013; Reinhold & Reiners 2013, 2015; García et al. 2014]
  - Internal (differential?) rotation through seismology [e.g. Beck et al. 2012; Deheuvels et al. 2012,2014,2015; Mosser et al. 2012, Nielsen et al. 2014, Benomar et al. 2016, Pia di Mauro et al. 2016,
- Convection properties
  - Characteristic time scale of convection (granulation) [e.g. Mathur et al. 2011; Kallinger et al. 2014, 2016]
    - other scales:
      - » e.g. Faculae in active stars [e.g. Karoff et al. 2013]
- Internal structure (through seismology) [e.g. Mathur et al. 2012; Mazumdar et al. 2014; Metcalfe et al. 2014,…]
  - Size of the convective envelope (through seismology (+ modelling))
  - Constraining deep internal magnetic fields & convective core dynamos [Fuller et al. 2015.; Stello et al. 2016a,b]
- Activity cycles & surface magnetism
  - Through the analysis of long time series (activity proxies) [e.g. García et al. 2010; Mathur et al. 2013, 2014, Salabert et al. 2016]
    - Or asteroseismology [e.g. García et al. 2010; Régulo et al. 2016]

credit of slide: R. García (CEA)

data rights

The SOC will generate the Level-0 and Level-1 products for all PLATO observed targets, including the Guest Observer (GO) programme observations.

Level-2 products will be generated by the PMC and delivered to the SOC for all observed targets, excluding those from the GO programme (see Section 5.2.2).

Level-3 products for the planets of the prime sample (see Section 4.2) will be generated by the PMC with inputs from the GOP Team (see Section 5.2.3).

The ground-based observations for the remaining candidates may be carried out by the community at large as part of the PLATO legacy. ESA will invite the community to provide their data and results, to make them accessible also through the PLATO Science Archive.

see PLATO Science Management Plan, 11.10.2017

The release of PLATO data products will be based on the following scheme. After the first quarter of observations and delivery of Level-0 and Level-1 products by the SOC to the PMC, 6 months will be required for Level-1 data validation (and updating of the pipeline), while for the following quarters, 3 months will be needed. The public release of Level-0, Level-1 and Level-2 products for each observation quarter will be made as soon as possible, but no later than one year after the end of each Level-1 product validation period. Three months have been taken here as the data processing unit because it corresponds to the time duration between the 90° rotations of the spacecraft. The "data delivery" timeline is shown in Figure 4.

The identification of the planet candidates and, therefore, the kick-off of the ground-based observations for each target will depend on the quality of the transit detection and on the period of the planet. For the most difficult cases of Earth-size planets orbiting a solar-type star at 1 AU, it may take ~2 years to observe and confirm the transit. Then ~1 year will be needed for planet confirmation by ground-based observations and ~2 years to carry out the radial velocity observations. For shorter period Earth-size planets and for Jupiters or Neptunes from six months to 2 years will be needed to observe and confirm the transit, from 6 months to 1 year for confirmation by ground-based observations and from 6 months to 1 year to carry out the radial velocity observations. The timeline for these two examples in the "prime sample" is shown in Figure 4. Consequently ground-based observations will continue after the end of nominal science operations, for planet confirmation and for radial velocity measurements as indicated in Table 2.

see PLATO Science Management Plan, 11.10.2017

data rights

Level-3 data of the prime sample (delivered by the PMC) and their ground-based associated observations (provided by the GOP Team) will be publicly released immediately after the publication of the planetary parameters, or as soon as possible but no later than six months after the completion of the ground-based observations (see the examples in the "prime sample" in Figure 4). When papers are published by the PMC and/or GOP using data from proprietary targets, the validated data associated with those targets will be simultaneously publicly released in the PLATO Science Archive.

Ground-based observations data for targets in the prime sample, which are not confirmed to be planets, will also be made publicly available in the PLATO Science Archive as soon as possible but no later than six months after the completion of the ground-based observation programme for each target.

The previous approach excludes all the products associated with the proprietary targets allocated to the GO programme (see Section 5.2.2) and to the PMC (see below), for which the following proprietary times will be granted.

see PLATO Science Management Plan, 11.10.2017

data rights

The proprietary time of the targets selected through the GO programme call will be one year, starting counting at the time of the SOC delivery to the observer of the last portion of the observation Level-1 data. During the execution of the observations, the SOC will deliver Level-0 and Level-1 products to the observer every three months (see "Guest Observers" timeline in Figure 4).

The proprietary targets allocated to the PMC will be selected using the first 3 months of PLATO observation of each field. First, from the prime sample with brightness $m_V < 11$ for each sky field, the stars belonging to the lowest quartile (25 %) of the noise distribution will be identified. Of these, 25% will be selected, with a noise distribution similar to that of the original sample. The maximum number of proprietary targets allocated to the PMC will not exceed 2000 in total over the 4.2 years of nominal mission duration. The proprietary target list will be submitted by the PMC to ESA for review and approval. The GOP Team will be fully involved by the PMC in the scientific exploitation of the proprietary targets. Their proprietary period will cover the duration of the PLATO observation, and will end six months after the completion of the ground-based observations for the confirmation and characterisation of the associated planets (see example of "proprietary target" timeline in Figure 4). The proprietary period will finish in any case at the end of the mission archival phase (see Section 2.2).

see PLATO Science Management Plan, 11.10.2017